HETA 98–0131–2704
U.S. Precision Lens Incorporated
Cincinnati, Ohio

Nancy Clark Burton, M.P.H., M.S., C.I.H.

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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Health Hazard Evaluation Report 98–0131–2704
U.S. Precision Lens Incorporated
Cincinnati, Ohio
August 1998

Nancy Clark Burton, M.P.H., M.S., C.I.H.

SUMMARY

In March 1998, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the management at U.S. Precision Lens, Inc. (USPL) in Cincinnati, Ohio. The HHE request asked for assistance in evaluating workers' exposures to an acrylic polymer (Shinkolite–P UT–100), specifically the component n–cyclohexylmaleimide (n–CHMI). The polymer is used in the production of lenses for large screen projection television sets. In response to this request, an initial site visit was conducted on March 18, 1998, to collect bulk samples of the raw material for volatile organic compounds (VOCs) analysis and observe the production process. Additional site visits were conducted on April 14, 1998, and April 30, 1998, to collect environmental air samples for n–CHMI, VOCs, methyl methacrylate (MMA), and styrene. Informal employee interviews were conducted with 13 individuals involved in UT–100 production during these site visits.

In the bulk polymer material, MMA was the major component detected. n–CHMI, styrene and alpha–methyl styrene were also detected. For the VOCs air sampling, the major compounds detected were isopropanol, trichloroethylene, and MMA. Other compounds detected include n–CHMI, dimethyl ether, styrene, alpha–methyl styrene, limonene, aliphatic acid esters, nicotine, chlorofluoro hydrocarbons, xylene, butyl cellosolve, methyl ethyl ketone, and some fragrance compounds. Two sets of environmental monitoring data were collected for n–CHMI, one to determine if the analytical method would work and one to obtain a lower analytical limit of detection. The area air sample concentrations ranged from non–detectable to 340.6 micrograms per cubic meter ($\mu g/m^3$) for the first data set, including a purge cycle, and from trace levels to 0.88 $\mu g/m^3$ for the second data set. The personal breathing zone air concentrations ranged from non–detectable to trace levels for the first data set and from trace levels to 3.82 $\mu g/m^3$ for the second data set. One employee stated that they experienced symptoms of congestion and nausea during the purge process. None of the other 12 employees reported any problems working with the UT–100 product.

The highest exposures to n–CHMI appear to be during the purge process. The purge process takes less than ten minutes to complete and the employees who run the purge did not report any health symptoms. There are no established occupational exposure limits for n–CHMI. Styrene and MMA, known irritants of the eye, nose, and throat, were not detected during the sampling period. Recommendations to add a local exhaust hood to capture emissions from the purge process, and to evaluate potential exposures to maintenance personnel are presented on page 6.

Keywords: SIC Code 3089 (Plastics Products, Not Elsewhere Classified), television lens, injection molding, (Shinkolite–P UT–100), n–cyclohexylmaleimide, n–CHMI, styrene, methyl methacrylate.

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INTRODUCTION

In March 1998, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the management at U.S. Precision Lens, Inc. (USPL) in Cincinnati, Ohio. The HHE request asked for assistance in evaluating workers' exposures to an acrylic polymer (Shinkolite–P UT–100), specifically the component, n–cyclohexylmaleimide (n–CHMI). The manufacturer of the polymer had recently provided additional toxicity data on n–CHMI to USPL and had lowered its suggested exposure limit. In response to this request, an initial site visit was conducted on March 18, 1998, to collect bulk samples of the raw material and observe the production process. Additional site visits were conducted on April 14, 1998, and April 30, 1998, to collect environmental air samples.

BACKGROUND

U.S. Precision Lens, Inc. manufactures lenses for large screen projection television sets as well as other lens products. The acrylic polymer, Shinkolite–P UT–100, is a combination of methyl methacrylate, alpha–methyl styrene, styrene, and n–CHMI, the latter making the product more heat resistant. The lens production process is continuous. Production employees work on teams in 12–hour shifts and rotate through a two–week schedule (every other weekend off). Engineers may also work in the production area if their project uses UT–100.

The robotic plastic injection molding machines are enclosed except at the top. The acrylic polymer pellets are dried, preheated, and vacuum–fed into the hopper of the molding machine. Mechanical rotation and friction are used to melt the pellets. If the process temperature exceeds 500°F, emergency alarms sound, and the molding machine shuts–off automatically. The liquid material is injected into the metal mold and allowed to solidify. The parts are cool at this point and the operators visually inspect them. The injection molding machine barrels are heated and purged (old material is removed) before being restarted.

The robotic injection molding machines are housed in the video optics molding (VOM2) area. The VOM2 area is a large open space which is serviced by a single ventilation system. The ventilation system is set–up to provide 14 air changes per hour (ACH). The return air is filtered through a high efficiency particulate (HEPA) air filter with 17% outside make–up air. The ventilation system has an emergency setting which purges all of the air in VOM2. A ventilation assessment was completed by a private consultant in March 1998, and showed that contaminants moved away from the employees toward the wall returns located above the floor. Supply air is provided through ceiling diffusers, and four large exhaust grilles are located in the back wall.

The same private consulting firm conducted environmental air monitoring in November 1997, for methyl methacrylate, styrene, alpha–methyl styrene, and n–CHMI. None of the compounds were detected at the analytical limits of detection of 0.17 parts per million (ppm), 0.078 ppm, 0.069 ppm, and 0.0093 milligrams per cubic meter (mg/m^3), respectively. Environmental air sampling for n–CHMI was conducted using a combination glass fiber filter and tenax tube in series. The samples were analyzed using high pressure liquid chromatography with an ultraviolet detector.

METHODS

Bulk Sample of UT–100

A method was developed for n–CHMI at NIOSH. First, the bulk material was heated to the process temperature of 260°C (500°F) and air from the headspace was sampled using a thermal desorption tube containing three beds of sorbent material. The sample was analyzed using a Tekmar thermal desorber interfaced directly to a gas chromatograph and a mass selective detector (TD–GC–MSD). A laboratory standard of n–CHMI was also obtained. Stock solutions in acetone, containing known amounts of n–CHMI were used to prepare standards to determine concentrations. The spike samples were prepared by inserting blank thermal desorption tubes into a GC injector and aliquots of the standard stock solutions were injected and analyzed as described above.

Qualitative Analysis of Volatile Organic Compounds (VOCs)

Four personal breathing zone (PBZ) and eight area air samples were collected on April 14, 1998, on thermal desorption tubes and qualitatively analyzed by TDGC–MSD for VOCs.

n–Cyclohexylmaleimide (n-CHMI)

The four PBZ and eight area air samples collected on April 14, 1998, were also analyzed for n–CHMI. For this data set, the analytical limit of detection (LOD) was 0.007 micrograms (µg), which is equivalent to a minimum detectable concentration (MDC) of 0.625 micrograms per cubic meter (µg/m^3) assuming a sample volume of 11.2 liters. The limit of quantitation (LOQ) was 0.025 µg, which is equivalent to a minimum quantifiable concentration (MQC) of 2.23 µg/m^3, assuming a sample volume of 11.2 liters.

An additional five PBZ and four area air samples were collected on thermal desorption tubes on April 30, 1998, for n–CHMI for a longer sampling period. The thermal desorption tubes were also analyzed by TD–GC–MSD. The LOD was 0.004 µg, which is equivalent to a MDC of 0.21 µg/m^3, assuming a sample volume of 18.9 liters. The LOQ was 0.012 µg, which is equivalent to a minimum quantifiable concentration MQC of 0.63 µg/m^3, assuming a sample volume of 18.9 liters.

Styrene

Five area air samples for styrene were collected at a flowrate of 0.05 L/min using charcoal tubes and analyzed for toluene and styrene according to NIOSH Method 1501 using GC/FID.[1] The analytical LOD was 0.004 mg, which is equivalent to a MDC of 0.047 ppm, assuming a sample volume of 19.78 liters. The LOQ was 0.01 mg, which is equivalent to a MQC of 0.119 ppm, assuming a sample volume of 19.78 liters.

Methyl Methacrylate (MMA)

Five area air samples for MMA were collected at a flowrate of 0.05 L/min using silica gel tubes and analyzed for MMA according to NIOSH Method 2537 using gas chromatography with a flame ionization detector (GC/FID).[2] The analytical LOD was 0.003 mg, which is equivalent to a MDC of 0.037 ppm, assuming a sample volume of 20.06 liters. The LOQ was 0.008 mg, which is equivalent to a MQC of 0.098 ppm, assuming a sample volume of 20.06 liters.

Informal Employee Interviews

Informal interviews were conducted with 13 employees, who were working during the shifts when environmental air monitoring was conducted, to ascertain if they had any health complaints or issues related to working with the UT–100 product. These individuals were selected because they were working with the UT–100 material while the NIOSH investigators were at the worksite.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[3] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[5]. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to–10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

n–Cyclohexylmaleimide (n-CHMI)

An extensive literature search failed to locate published studies concerning the toxicity or health effects associated with occupational exposure to n-CHMI. The material safety data sheet (MSDS) for this product lists it as a severe eye and respiratory irritant. Mitsubishi Rayon America, the manufacturer of the UT–100 material, provided information to USPL on two acute inhalation studies using rats exposed to n–CHMI. No data was provided on chronic effects. The first study used 30 rats (five control animals and two sets of exposed animals [five in each group] for each sex). Experimental Group 1 (five males and five females) was exposed to 13 mg/m^3 of n–CHMI particulate aerosol for 4 hours and Experimental Group 2 (five males and five females) was exposed to 15 mg/m^3 n–CHMI vapor for 4 hours. In Experimental Group 1, 8 of the 10 rats (3 males and 5 females) died at that exposure level. They exhibited symptoms of exposure to an irritant aerosol including partial closure of the eyes, wetness around the nose and mouth, abnormal respiration, and death. None of the animals in Experimental Group 2 died. They showed similar signs of an exposure to irritant aerosol and had no residual symptoms by the fourth day of follow–up.

In the other study, a series of animals was exposed to n–CHMI concentrations of 550 $\mu g/m^3$, 250 $\mu g/m^3$, and 50 $\mu g/m^3$ for 6 hours per day for 28 days. Rats at the highest exposure level showed a decrease in weight, a decrease in food intake, and developed upper trachea irritation. Rats exposed at 250 $\mu g/m^3$ showed some decrease in weight, a decrease in food intake in males, and developed upper trachea irritation. Rats exposed at 50 $\mu g/m^3$ developed slight irritation of the upper trachea.

Mitsubishi Rayon America has established a suggested exposure limit of 0.6 $\mu g/m^3$ for n–CHMI. The suggested exposure limit is based on a risk assessment formula that used 50 $\mu g/m^3$ as the exposure factor from the inhalation study mentioned above and conversion factors to account for the animal toxicity data. A large safety factor of 500 was used in the risk assessment to obtain the suggested exposure limit. The MSDS also recommends that respiratory protection (dust masks), chemical resistant gloves, and local exhaust ventilation be used at all times to prevent exposure to n–CHMI.

Styrene

Styrene is used as a solvent in the plastics industry and as a monomer for plastics, fiberglass resins, and synthetic rubber elastomers.[6] Styrene is readily absorbed by inhalation and can be stored in fat tissue. Prolonged skin exposure can result in rash or dermatitis.[7] It can cause eye, nose, and throat irritation.[8] Styrene can cause CNS effects, such as headache, listlessness, and drowsiness.[6] Several studies have documented weakness, increased reaction times, and abnormal electroencephalograms in workers exposed to styrene.[6,9,10,11] Air concentrations of styrene were either undocumented or at times exceeded 100 ppm for some of the employees in these studies.

OSHA has established an 8–hr TWA PEL of 100 ppm for styrene.[5] ACGIH has established an 8–hr TWA TLV for styrene of 20 ppm.[4] NIOSH has established a 10–hr TWA–REL of 50 ppm for styrene.[3]

Methyl Methacrylate (MMA)

Methyl methacrylate (MMA) polymers or copolymers are widely used in the production of coatings, dental restorations, plastics, and surgical implants.[7] Exposure to MMA can cause irritation of the eyes, skin, throat, and respiratory tract; gastrointestinal irritation (nausea, vomiting, and diarrhea); and central nervous system effects (dizziness, drowsiness, weakness, fatigue, and unconsciousness).[6,12] Workers who were exposed to air concentrations between 0.5 ppm and 50 ppm reported a high incidence of headache, pain in the extremities, irritability, loss of memory, excessive fatigue, and sleep disturbances.[7] OSHA, ACGIH, and NIOSH have established occupational exposure criteria of 100 ppm for MMA as a TWA over the workshift.[3,4,5]

RESULTS/DISCUSSION

Bulk Sample of Polymer

A copy of the chromatogram from the headspace analysis of the bulk UT–100 sample is included in Appendix A, along with a list of the substances identified in the chromatogram. Methyl methacrylate was the major component detected. n–CHMI, styrene and alpha–methyl styrene were also detected. Other compounds identified include formic acid, benzoic acid, fatty acids, acetic acid, and various unidentified alkyl nitrogen containing compounds such as amines and nitriles.

Qualitative Analysis of Volatile Organic Compounds (VOCs)

Copies of the chromatograms for the VOCs analyses are included in Appendix B, along with a list of the substances identified in the chromatograms. The major compounds detected were isopropanol, trichloroethylene, and MMA. Other compounds detected include n–CHMI, dimethyl ether, styrene, alpha–methyl styrene, limonene, aliphatic acid esters, nicotine, chlorofluoro hydrocarbons, xylene, butyl cellosolve, methyl ethyl ketone, and some fragrance compounds. Some of these could be created from the heating of the UT–100 and others could be from cleaning products used in the work area.

n–Cyclohexylmaleimide (n-CHMI)

Two sets of environmental monitoring data were collected for n–CHMI. The air monitoring data from April 14, 1998, and April 30, 1998, are presented in Tables 1 and 2, respectively. The two area samples

(40.6 and 340.6 µg/m^3) collected during the first sampling period (Table 1) for the purge process show the highest levels of n–CHMI. These samples were collected next to the large mound of extruded material as it cooled, to ensure that n–CHMI could be detected using the thermal desorption tubes. There were no employees in the immediate vicinity when the samples were collected. The PBZ concentrations ranged from non–detectable to trace levels for the first data set and from trace levels to 3.82 µg/m^3 for the second data set (Table 2). The second set of data was collected for a longer time period to obtain a better estimate of exposure during the workday. The area samples collected near the mold exhaust ranged from non–detectable to 1 µg/m^3.

Styrene

The area air sampling results for styrene are shown in Table 3. Styrene was not detected in the area air samples at a MDC of 0.12 ppm.

Methyl Methacrylate (MMA)

The area air sampling results for MMA are presented in Table 4. MMA was not detected in the area air samples at a MDC of 0.1 ppm.

Informal Employee Interviews

One individual stated that they experienced symptoms of congestion and nausea during the purge process. According to employees, the purge process occurs about once a shift. The symptoms dissipated shortly after the purge was completed. None of the other 12 employees reported any problems working with the UT–100 product. Several of the employees reported working with the product for more than three years.

CONCLUSIONS

The highest exposures to n–CHMI appear to be during the purge process, but it is a short–term activity and the employees who do the job activities do not stay in the vicinity of the press or report any health symptoms. The one PBZ sample concentration for n–CHMI collected on the individual conducting the purge was non–detected. Some of the exposures were above the manufacturer's suggested exposure limit for n–CHMI but there is limited toxicity data available for n–CHMI. Concentrations of styrene and MMA, known irritants of the eye, nose, and throat, were non–detectable during the sampling period. Monitoring was not conducted during maintenance activities, therefore, we cannot comment on exposures during those activities.

RECOMMENDATIONS

1. To reduce the level of irritating contaminants that enter the workplace environment during the purge process, a portable local exhaust ventilation hood could be used.

2. Environmental monitoring of employee exposures during maintenance operations could be completed to ensure these employees are not over–exposed to substances in the UT–100.

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Table 1
n–Cyclohexylmaleimide Air Sampling Results
U.S. Precision Lens, Inc.
Cincinnati, Ohio
HETA 98–0131
April 14, 1998

Press Location	Sample Time	Sample Volume (liters)	n–Cyclohexylmaleimide Concentration (µg/m^3)*
Personal			
#31 – Press Associate	8:52 a.m. – 11:06 a.m.	6.7	ND**
#47 – Press Associate	8:45 a.m. – 12:46 p.m.	12.05	ND
#33 – Press Associate	8:48 a.m. – 10:55 a.m.	6.35	Trace^
#32 – Press Associate	8:43 a.m. – 12:43 p.m.	12	Trace
Area			
#47 – Screw Heating Element	9:04 a.m. – 12:50 p.m.	11.3	Trace
#32 – Screw Heating Element	9:01 a.m. – 11:02 a.m.	6.05	ND
#32 – Screw Heating Element	9:01 a.m. – 11:02 a.m.	6	ND
#47 – Screw Heating Element	9:06 a.m. – 12:50 p.m.	11.2	Trace
#33 – Mold Exhaust	9:20 a.m. – 12:55 p.m.	10.75	2.9
#32 – Mold Exhaust	9:20 a.m. – 12:59 p.m.	10.95	Trace
#48 – Screw Heating Element	9:11 a.m. to 10:52 a.m.	5.05	40.6^^
#48 – Screw Heating Element	9:11 a.m. to 10:52 a.m.	5.05	340.6^^
Minimum Detectable Concentration (MDC)		11.2	0.625
Minimum Quantifiable Concentration (MQC)		11.2	2.23

* = µg/m^3 – micrograms per cubic meter
** = ND – Not detected at MDC
^ = Trace – Concentration between MDC and MQC
^^ = Collected during purge process

Table 2
n–Cyclohexylmaleimide Air Sampling Results
U.S. Precision Lens, Inc.
Cincinnati, Ohio
HETA 98–0131
April 30, 1998

Press Location	Sample Time	Sample Volume (liters)	n–Cyclohexylmaleimide Concentration ($\mu g/m^3$)*
Personal			
#35 – Press Associate	9:09 a.m. – 4:06 p.m.	19.3	1.19
UT100 #46 – Press Associate	9:09 a.m. – 4:06 p.m.	21.5	1.16
UT100 #33 – Press Associate	8:58 a.m. – 9:14 a.m. 10:17 a.m. – 2:05 p.m. 2:20 p.m. – 4:32 p.m.	18.9	3.82
UT100 #32 – Press Associate	9:03 a.m. – 4:35 p.m.	22.2	0.99
Purge Operator	2:29 p.m. – 2:52 p.m.	1.1	Trace**
Area			
#33 – Screw Heating Element	9:27 a.m. – 4:15 p.m.	20.2	Trace
#32 – Mold Exhaust	9:23 a.m. – 4:21 p.m.	20.8	Trace
#46 – Mold Exhaust	9:20 a.m. – 4:19 p.m.	20.5	0.88
#33 – Mold Exhaust	9:26 a.m. – 4:20 p.m.	20.7	0.77
Minimum Detectable Concentration (MDC)		18.9	0.21
Minimum Quantifiable Concentration (MQC)		18.9	0.63

* = µg/m3 – micrograms per cubic meter
** = Trace – Concentration between MDC and MQC

Table 3
Styrene Air Sampling Results
U.S. Precision Lens, Inc.
Cincinnati, Ohio
HETA 98–0131
April 30, 1998

Press Location	Sample Time	Sample Volume (liters)	Styrene Concentration (ppm)*
		Area	
#33 – Mold Exhaust	9:25 a.m. – 4:22 p.m.	20.78	ND**
#46 – Screw Heating Element	9:30 a.m. – 4:09 p.m.	19.78	ND
#33 – Screw Heating Element	9:28 a.m. – 4:25 p.m.	20.73	ND
#46 – Mold Exhaust	9:19 a.m. – 4:26 p.m.	20.8	ND
#32 – Mold Exhaust	9:23 a.m. – 4:28 p.m.	21.07	ND
ACGIH TLV			20
NIOSH REL			50
OSHA PEL			100
Minimum Detectable Concentration (MDC)		19.78	0.05
Minimum Quantifiable Concentration (MQC)		19.78	0.12

* = ppm – parts per million
** = ND – Not detected at MDC

Table 4
Methyl Methacrylate Air Sampling Results
U.S. Precision Lens, Inc.
Cincinnati, Ohio
HETA 98–0131
April 30, 1998

Press Location	Sample Time	Sample Volume (liters)	Methyl Methacrylate Concentration (ppm)*
Area			
#32 – Mold Exhaust	9:23 a.m. –4:24 p.m.	20.77	ND**
#46 – Screw Heating Element	9:30 a.m. – 4:10 p.m.	20.06	ND
#46 – Mold Exhaust	9:21 a.m. – 4:22 p.m.	21.05	ND
#33 – Mold Exhaust	9:26 a.m. – 4:16 p.m.	20.32	ND
#33 – Screw Heating Element	9:28 a.m. – 4:25 p.m.	20.7	ND
ACGIH TLV			100
NIOSH REL			100
OSHA PEL			100
Minimum Detectable Concentration (MDC)		20.06	0.04
Minimum Quantifiable Concentration (MQC)		20.06	0.10

* = ppm (parts per million)
** = ND (not detected at MDC)

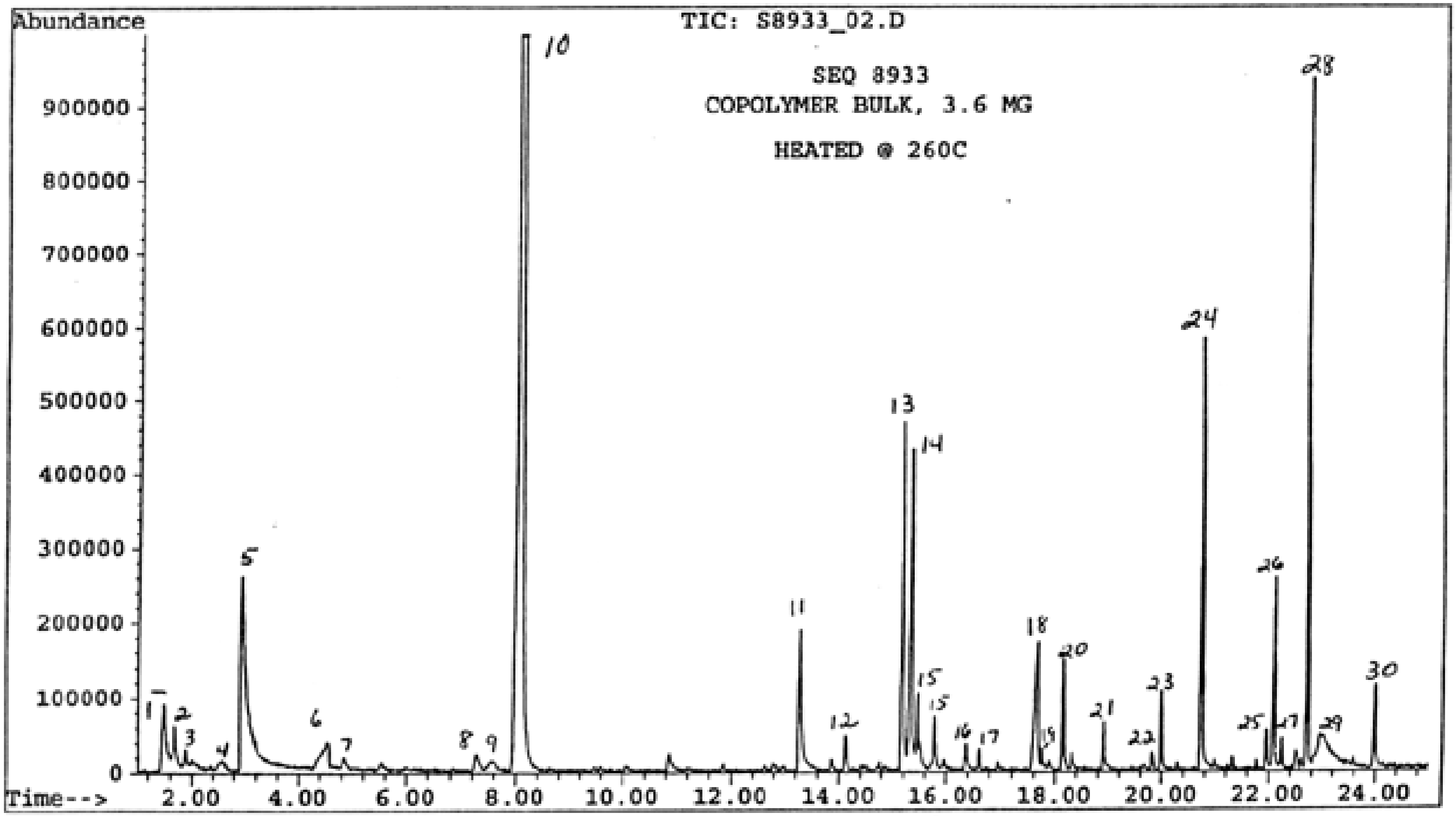
Appendix A
Bulk Sample Chromatogram

SEQ 8933
HEATED COPOLYMER, 260°C
PEAK IDENTIFICATION

1) Air
2) SO_2
3) Methanol
4) Acrolein?
5) Formic acid
6) Acetic acid
7) 2-Methylpropane nitrile
8) Methyl propanoic acid, methyl ester?
9) 2-Propenoic acid (acrylic acid)
10) **Methyl methacrylate**
11) **Styrene**
12) C_9H_{12} alkyl benzene (trimethyl-, propylbenzene, etc.)
13) **α-Methyl styrene**
14) Alkyl nitrile?
15) $C_{10}H_{14}$ alkyl benzene (t-butyl-, methylpropyl-, dimethylethyl benzene, etc.)
16) Acetophenone
17) Alkyl nitrogen compound, M.W.127?
18) Benzoic acid
19) Fatty acid (octanoic)
20) Unknown, alkyl compound
21) Fatty acid (nonanoic)
22) Phenyl compound, M.W.176
23) Fatty acid (decanoic)
24) **N-Cyclohexylmaleimide** (CHMI)*
25) Fatty acid (undecanoic?)26) Alkyl amine
27) Diethylphthalate
28) Nitrogen compound, M.W.207, possibly a dimethyl or ethyl substituted cyclohexylmaleimide?
29) Nitrogen compound
30) Nitrogen compound, mass spectrum similar to #28

*Matches spectrum and retention time of a standard spike of N-cyclohexylmaleimide.

File : C:\HPCHEM\1\DATA\S8933\S8933_02.D
Operator :
Acquired : 25 Mar 98 12:26 pm using AcqMethod PLASTIC
Instrument : 5970 - In
Sample Name: 3.6 MG COPOLYMER BULK HEATED 260C 10 MIN
Misc Info : 30 M DB-1 SC20-400 TP35-300
Vial Number: 2



Appendix B
Volatile Organic Chemicals Chromatograms

SEQ 8933AB
THERMAL DESORPTION TUBES
PEAK IDENTIFICATION

1) Air*/CO_2*
2) Propene/chlorotrifluoroethene
3) Dimethyl ether
4) Methanol
5) C_4H_8 isomer (butene, etc.)
6) Ethanol
7) Dibromomethane?
8) Acetonitrile
9) Acetone
10) Isopropanol
11) 1,1-Dichloro-1-fluoroethane
12) Methyl acetate
13) C_5H_8 isomer (pentadiene)
14) Methylene chloride
15) 1,1,2-Trichloro-1,2,2-trifluoroethane
16) 3-Buten-2-one
17) Methyl ethyl ketone (MEK)
18) Ethyl acetate
19) Methyl propanenitrile?
20) Methyl acrylate
21) Propanoic acid, methyl ester
22) 1,1,1-Trichloroethane
23) Butanol/benzene/propyl acetate
24) 1-Methoxy-2-propanol
25) 2-Methyl propanoic acid, methyl ester
26) Trichloroethylene
27) Methyl methacrylate
28) Methyl isobutyl ketone
29) Acrylate compound
30) Toluene
31) 2-Methyl butanoic acid, methyl ester
32) Butenoic acid
33) 2-Methylene butanoic acid, methyl ester
34) Hexanal
35) Butyl acetate
36) Furfural
37) Diacetone alcohol
38) Hexamethylcyclotrisiloxane*
39) Propylene glycol methyl ether acetate
40) Ethyl benzene/xylene isomers
41) Styrene
42) Butyl cellosolve
43) C_9H_{12} alkyl benzene
44) Acrylate compound
45) Benzaldehyde
46) α-Pinene
47) 6-Methyl-5-hepten-2-one
48) α-Methyl styrene
49) Propanenitrile, 2-methyl-, 2,2'azobis?
50) t-Butyl benzene
51) 2-Ethyl-1-hexanol
52) Limonene
53) Methyl butanedioic acid, dimethyl ester
54) Acetophenone
55) Methylene butanedioic acid, dimethyl ester
56) 2-Methyl pentanedioic acid, methyl ester
57) Dimethyl pentanedioic acid, dimethyl ester
58) Dimethyl pentenedioic acid, dimethyl ester?
59) Dimethyl hexanoic acid, methyl ester
60) C_8-C_{10} aliphatic aldehydes*
61) Ethyl hexyl acetate
62) Decamethylcyclopentasiloxane*
63) α-Terpineol
64) Piperonal
65) Nicotine
66) Methacrylate compound?
67) Hexanedioic acid, methyl, methylene, dimethyl ester
68) Benzenepropanoic acid, methylene, methyl ester
69) Cyclohexylmaleimide
70) M.W.204, phenyl compound?
71) Acid esters?
72) Dimethylphthalate*
73) Hexanedioic acid, bis(methylethyl) ester
74) α-Ionone, $C_{13}H_{20}O$
75) Linalyl acetate, $C_{12}H_{20}O_2$
76) β-Ionone, $C_{13}H_{20}O$
77) Lily aldehyde (lilial)
78) Geranyl acetone
79) 2,6-di-t-butyl-p-benzoquinone
80) BHT-quinone methide
81) Ionol
82) Diethylphthalate*
83) Dimethyl or ethyl substituted cyclohexylmaleimide?
84) Methyl dihydrojasmonate
85) Hexenyl salicylate
86) M.W.234, $C_{15}H_{22}O_2$ compound?
87) M.W.258, $C_{18}H_{26}O$ compound?
88) M.W.214, aliphatic, oxy-compound?
89) Tri-t-butyl-benzene

*Also present on field and/or media blanks.
Compounds in bold type were present as decomposition products of the copolymer in a previous analysis (Seq 8933AA).

```
File         : C:\HPCHEM\1\DATA\APRIL98\S8933_08.D
Operator     :
Acquired     : 15 Apr 98   3:21 pm using AcqMethod IMIDE
Instrument :    5970 - In
Sample Name: SAMPLE A05036 PURGED
Misc Info    : 30 M DB-1 SC20-300 TP35-300
Vial Number: 8
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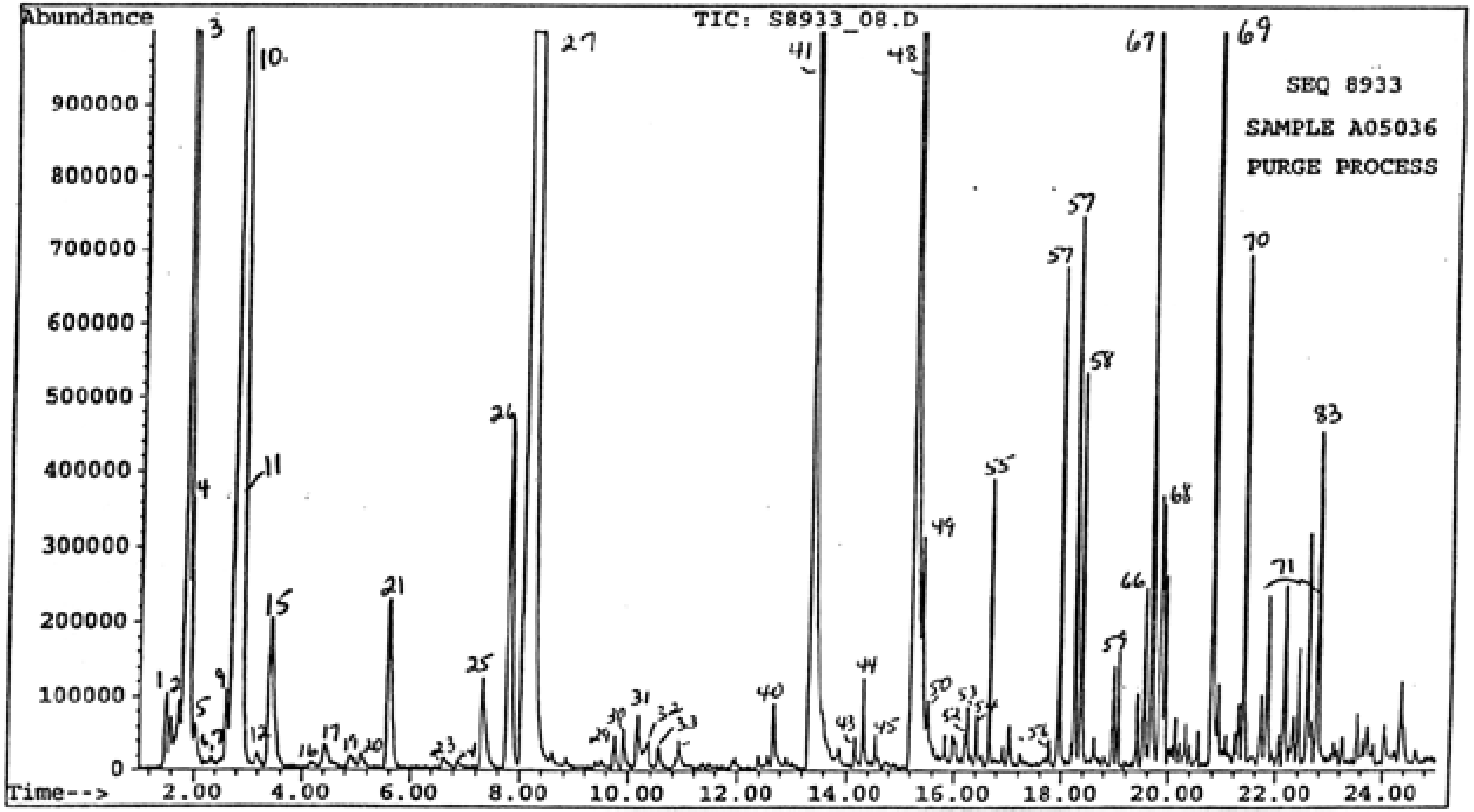

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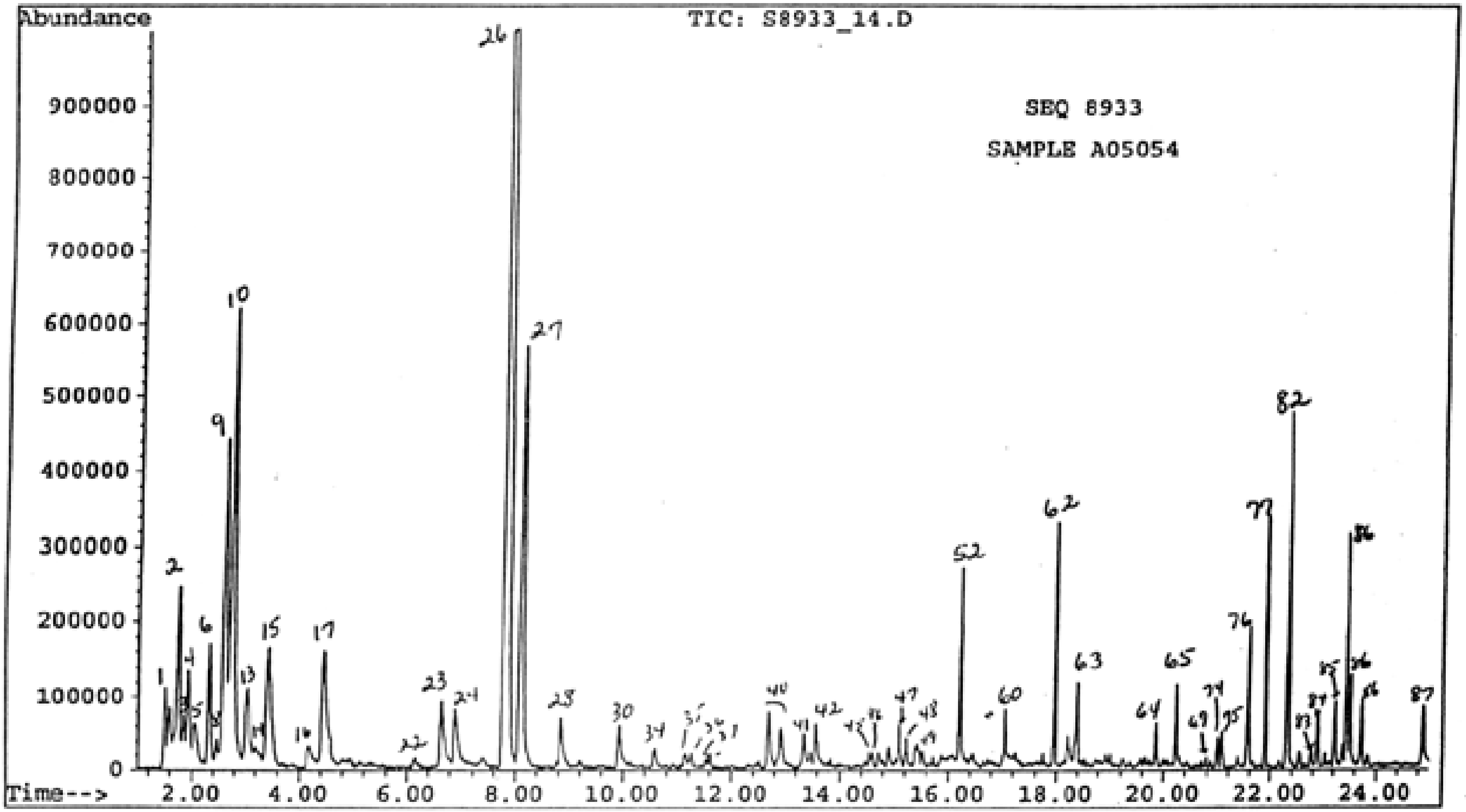
Acquired : 15 Apr 98 8:22 pm using AcqMethod IMIDE
Instrument : 5970 - In
Sample Name: SAMPLE A05054 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 14



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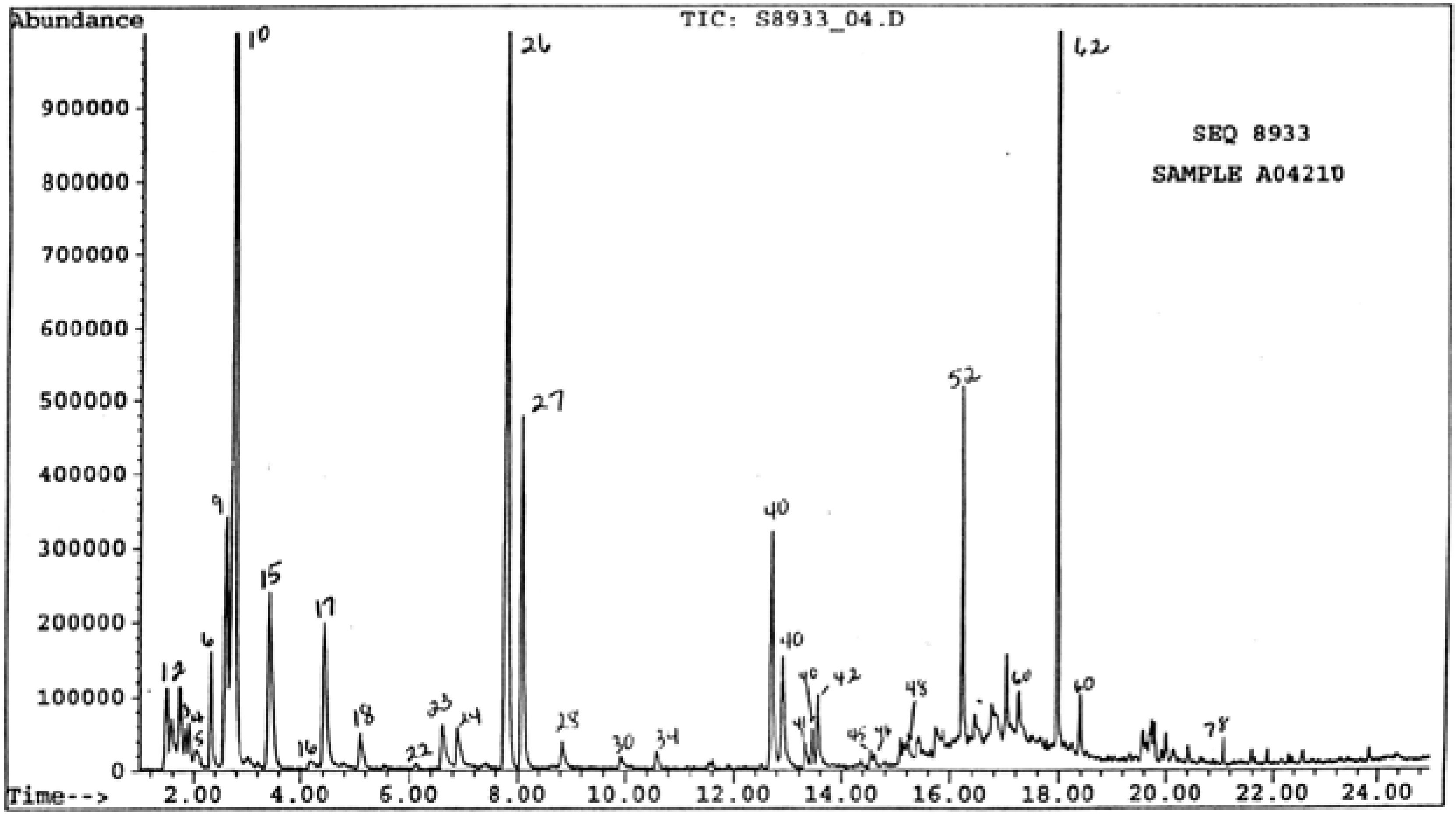
Acquired : 15 Apr 98 10:21 am using AcqMethod ATD
Instrument : 5970 - In
Sample Name: SAMPLE A04210 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 2



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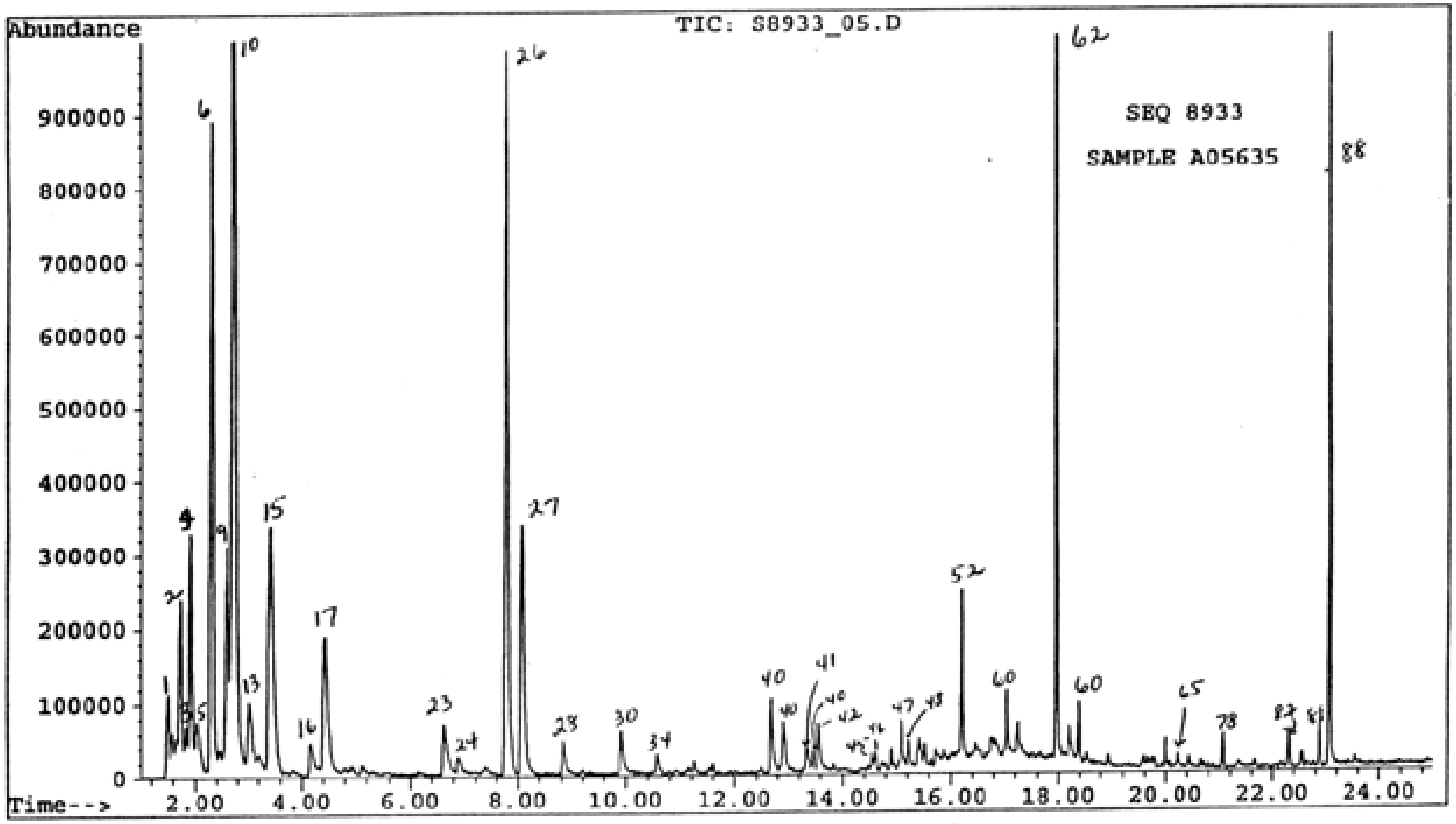
Operator :
Acquired : 15 Apr 98 11:10 am using AcqMethod IMIDE
Instrument : 5970 - In
Sample Name: SAMPLE A05635 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 3



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Operator     :
Acquired     : 15 Apr 98  11:59 am using AcqMethod IMIDE
Instrument :    5970 - In
Sample Name: SAMPLE A04702 PURGED
Misc Info    : 30 M DB-1 SC20-300 TP35-300
Vial Number: 4
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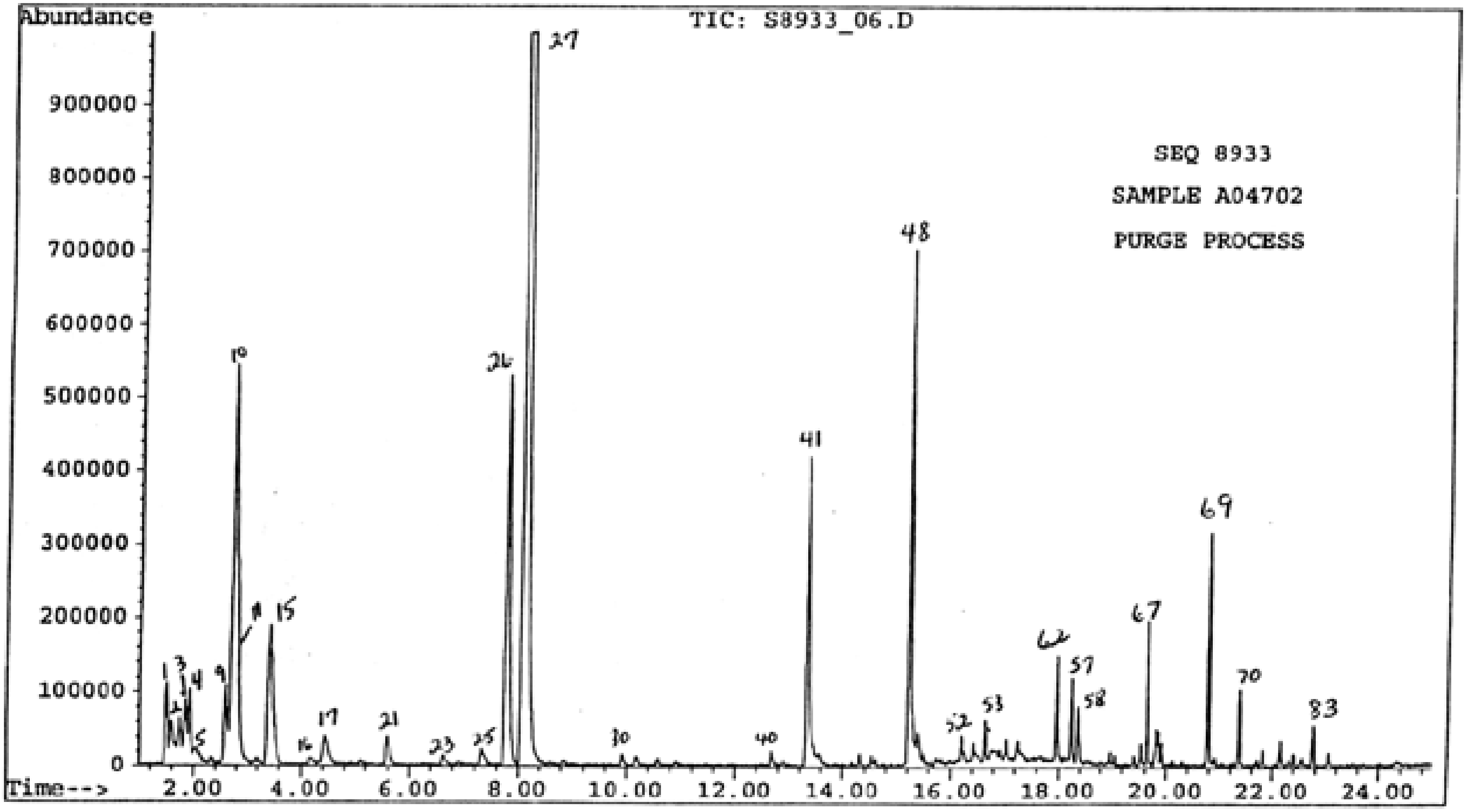

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Operator     :
Acquired     : 15 Apr 98  12:48 pm using AcqMethod IMIDE
Instrument :    5970 - In
Sample Name: SAMPLE A04150 PURGED
Misc Info   : 30 M DB-1 SC20-300 TP35-300
Vial Number: 5
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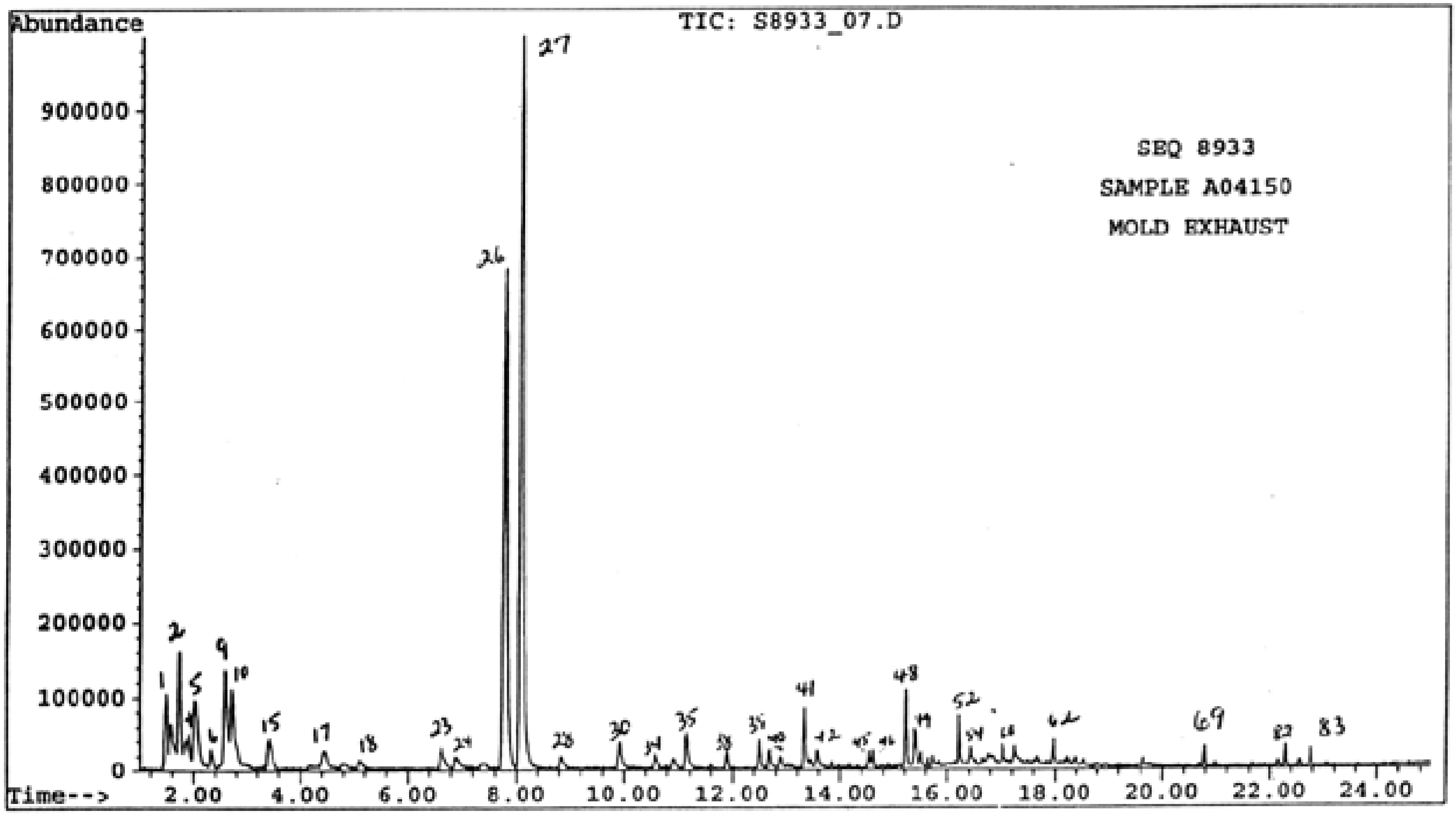

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Operator     :
Acquired     : 15 Apr 98   4:11 pm using AcqMethod IMIDE
Instrument   :   5970 - In
Sample Name: SAMPLE A05924 PURGED
Misc Info    : 30 M DB-1 SC20-300 TP35-300
Vial Number: 9
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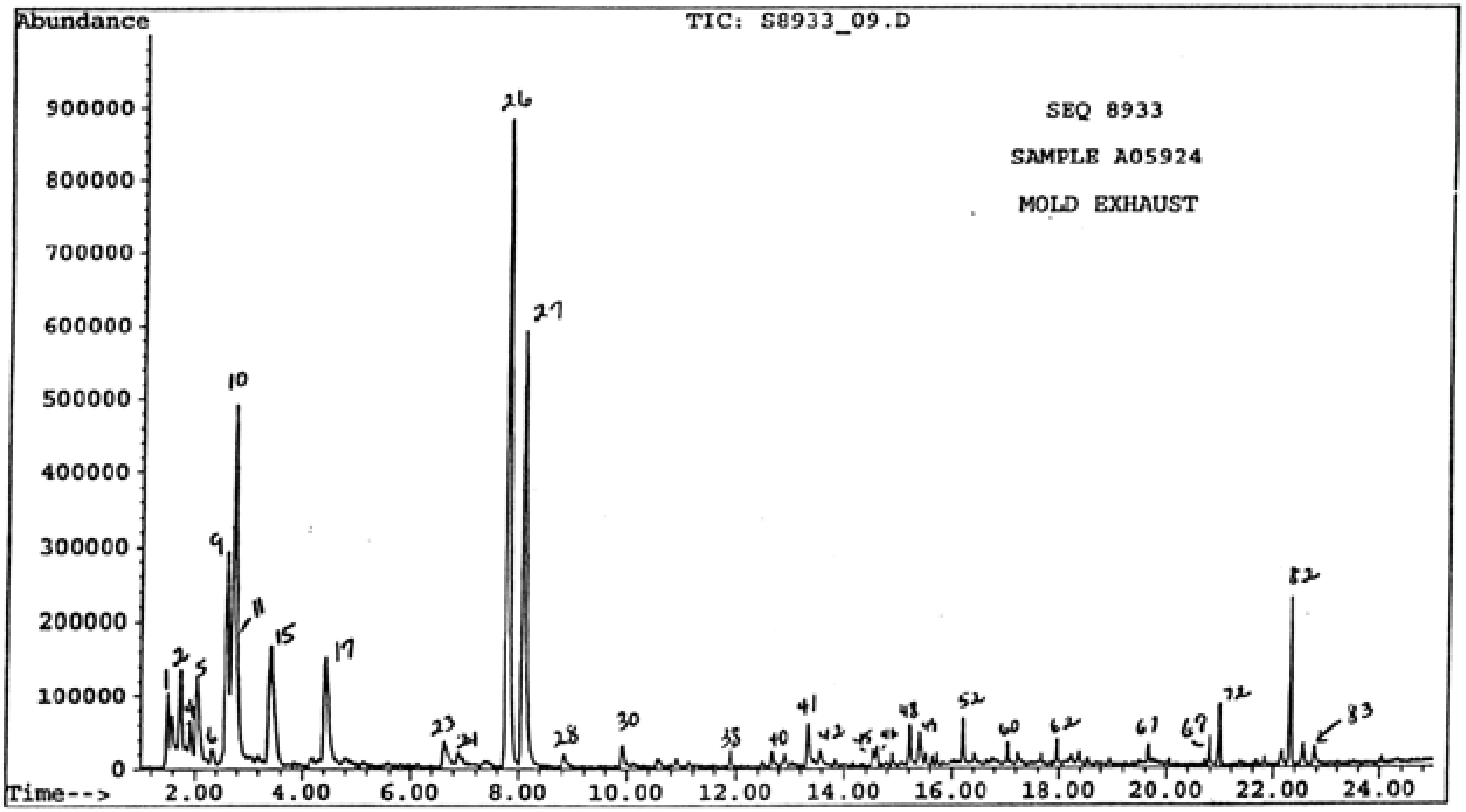

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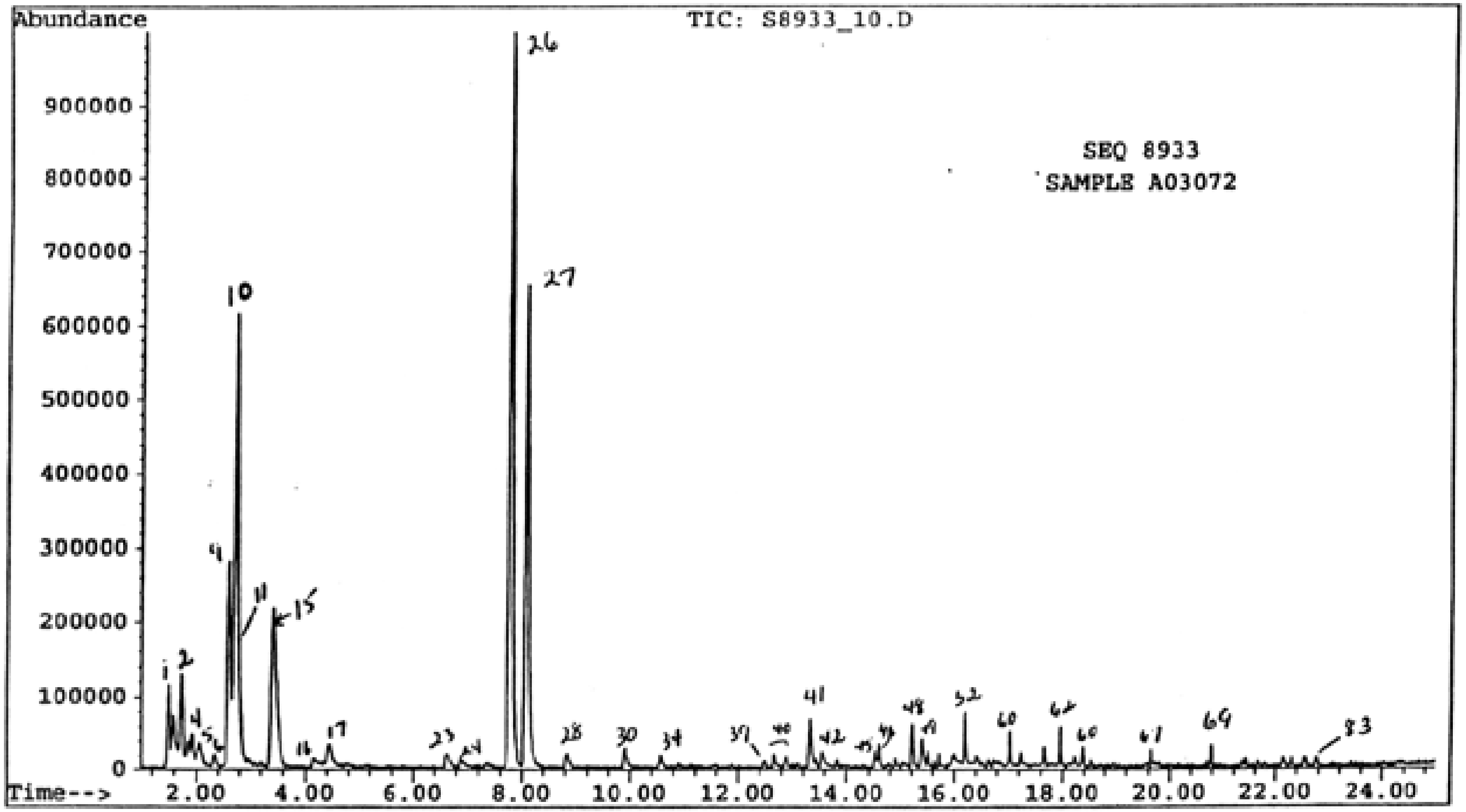
Acquired   : 15 Apr 98   5:01 pm using AcqMethod IMIDE
Instrument :   5970 - In
Sample Name: SAMPLE A03072 PURGED
Misc Info   : 30 M DB-1 SC20-300 TP35-300
Vial Number: 10



File : C:\HPCHEM\1\DATA\APRIL98\S8933_11.D
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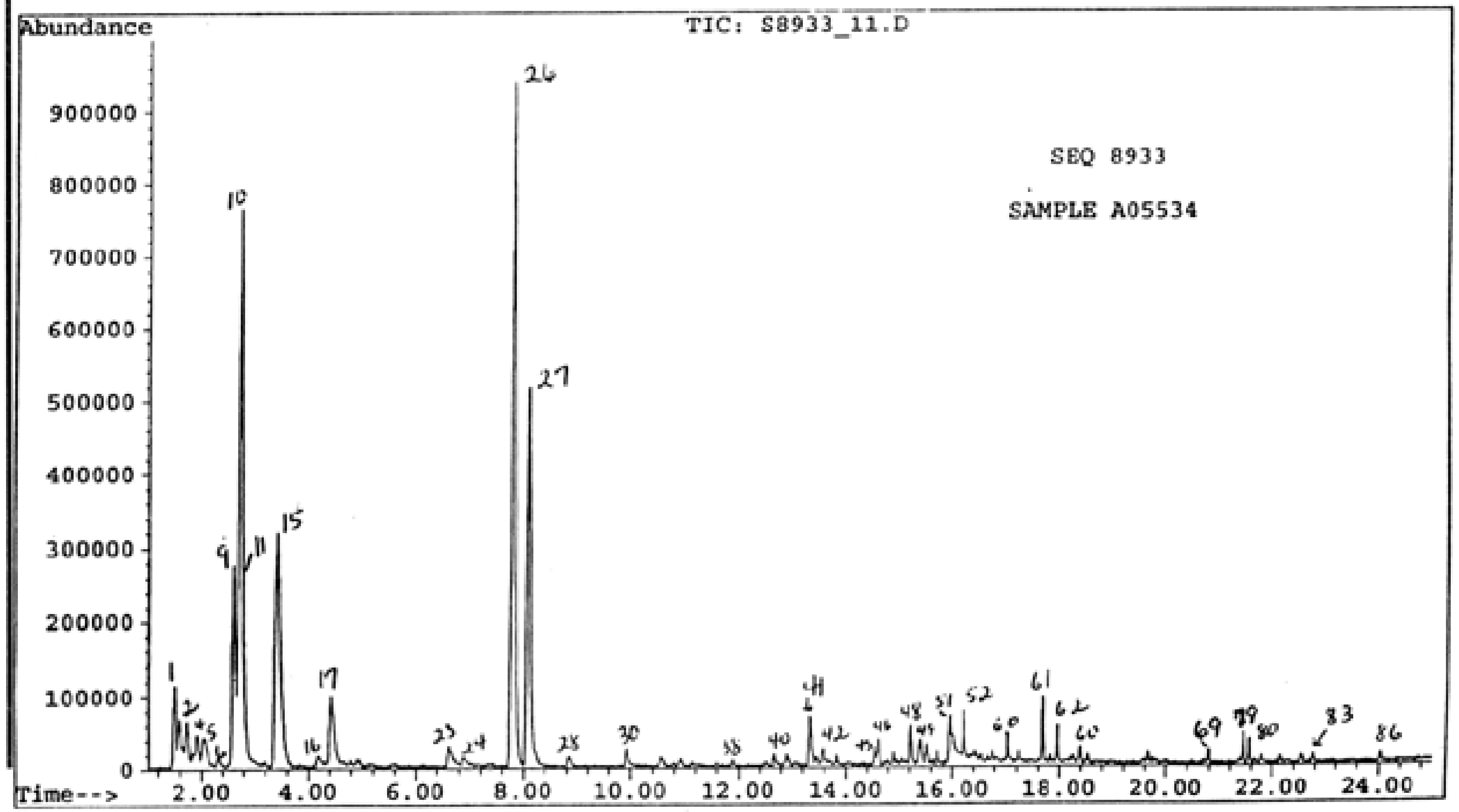
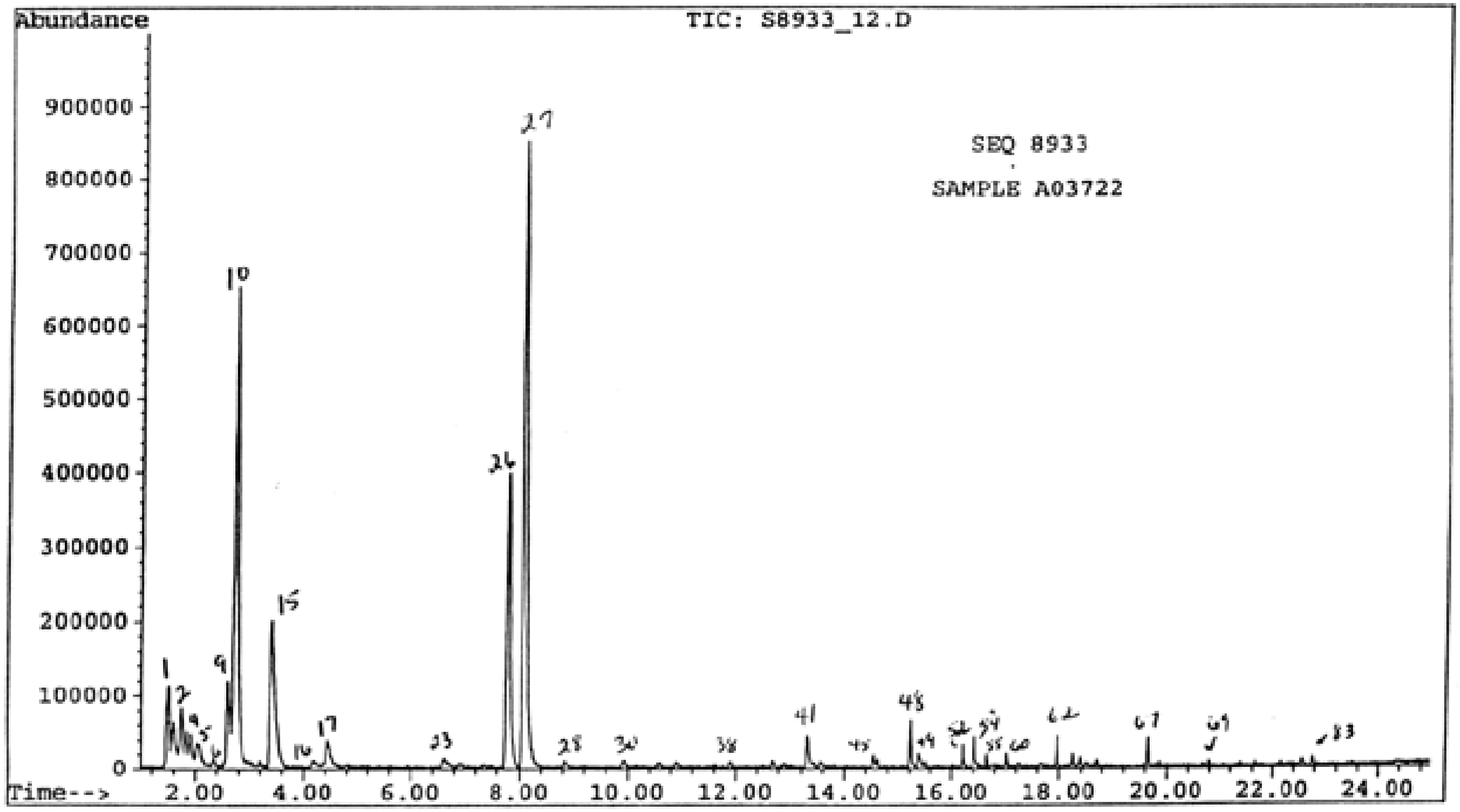
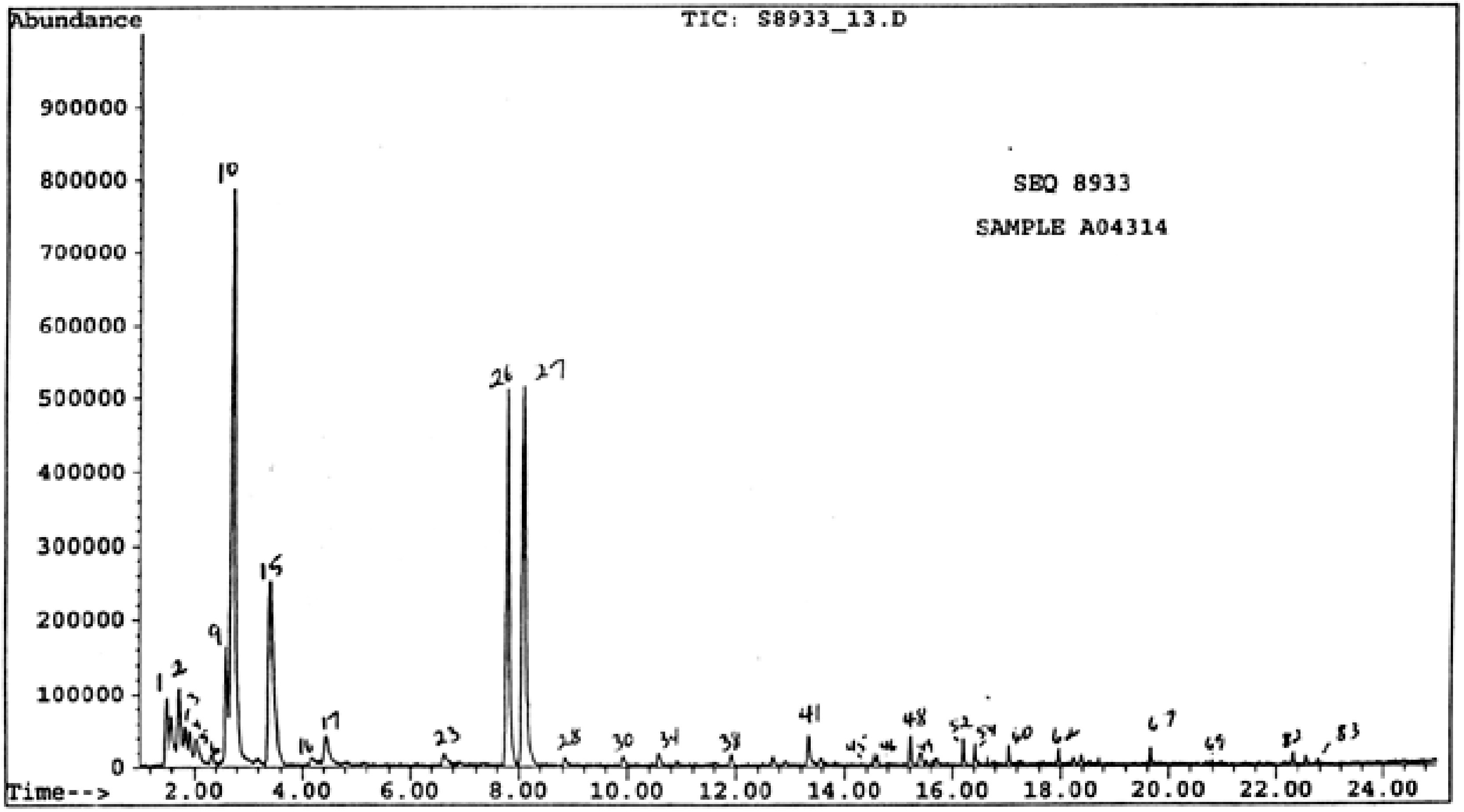
Acquired : 15 Apr 98 5:51 pm using AcqMethod IMIDE
Instrument : 5970 - In
Sample Name: SAMPLE A05534 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 11



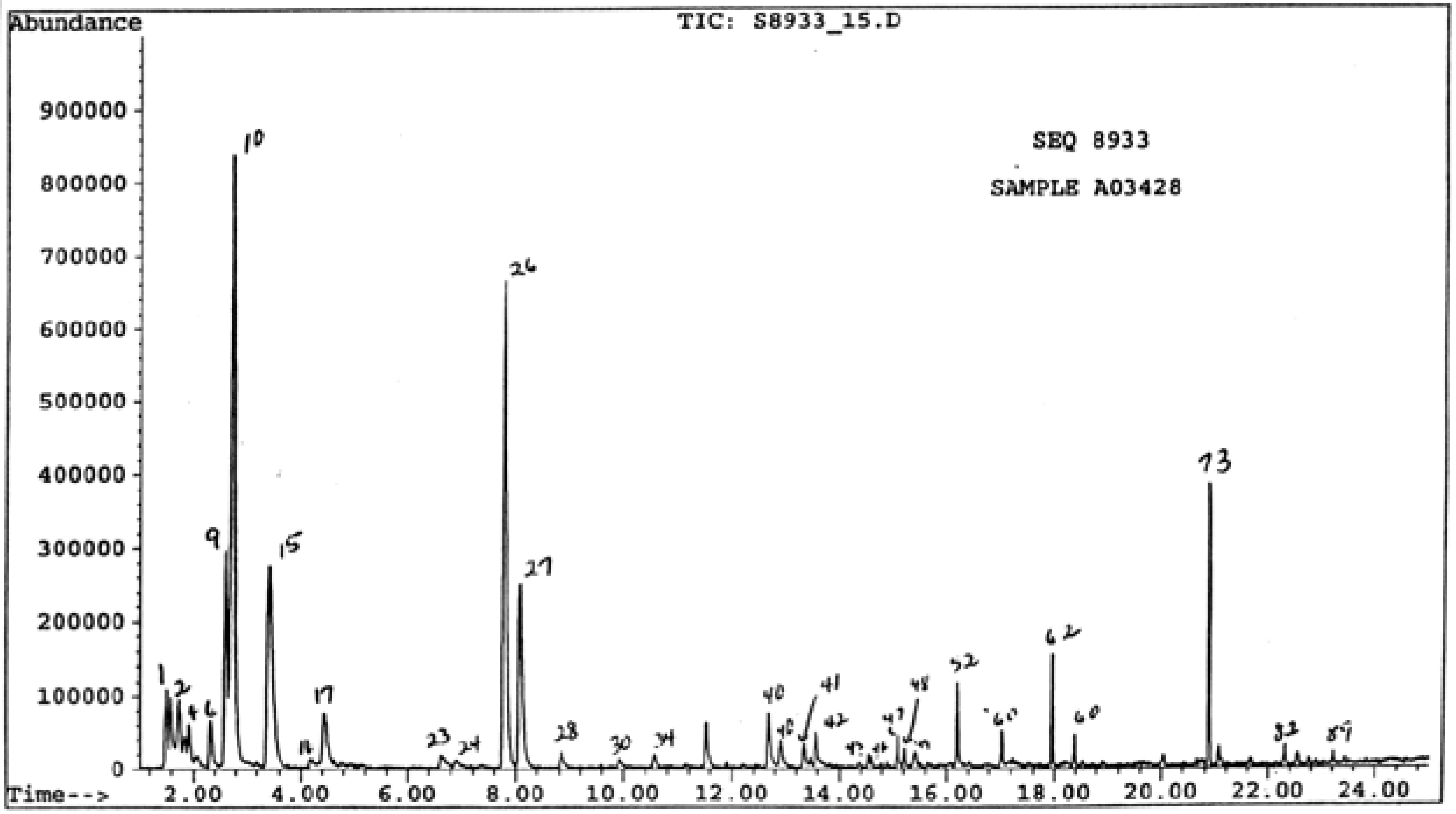
File : C:\HPCHEM\1\DATA\APRIL98\S8933_12.D
Operator :
Acquired : 15 Apr 98 6:41 pm using AcqMethod IMIDE
Instrument : 5970 - In
Sample Name: SAMPLE A03722 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 12



File : C:\HPCHEM\1\DATA\APRIL98\S8933_13.D
Operator :
Acquired : 15 Apr 98 7:31 pm using AcqMethod IMIDE
Instrument : 5970 - In
Sample Name: SAMPLE A04314 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 13



File   : C:\HPCHEM\1\DATA\APRIL98\S8933_15.D
Operator   :
Acquired   : 15 Apr 98   9:12 pm using AcqMethod IMIDE
Instrument :   5970 - In
Sample Name: SAMPLE A03428 PURGED
Misc Info   : 30 M DB-1 SC20-300 TP35-300
Vial Number: 15



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